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BIOLOGY AND CONSERVATION OF THE ENDANGERED INTERIOR LEAST TERN: A LITERATURE REVIEW

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**Biology and Conservation of the Endangered
Interior Least Tern: A Literature Review**

by

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Summary

An extensive literature review of the least tern (*Sterna antillarum*) was conducted with a special emphasis on the interior subspecies (*S. a. athalassos*). This was done to consolidate all available information necessary to formulate future management plans. This is particularly important since the interior population has been recently listed as federally endangered. The tern's taxonomy, description, range, life history, factors affecting population levels, present status, and management considerations were reviewed.

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Taxonomy

The least tern (*Sterna antillarum*) was first described by Lesson in 1847 (Ridgway 1895; American Ornithologist's Union 1957, 1983). More recently this bird was classified as a subspecies of the European little tern (*S. albigrons*; Burleigh and Lowery 1942). As a result of recent study on vocalizations, behavior, and limited morphology, Old and New World least/little terns are now considered separate species (Massey 1976). The species name has been returned to *S. antillarum* (American Ornithologist's Union 1983). Like many other species, the subspecific taxonomy of the least tern has been confusing. Some authors argue that the California (*S. a. brownii*) and eastern subspecies (*S. a. antillarum*) are the same (Burleigh and Lowery 1942; Massey 1976). Massey (1976) found no differences in these two subspecies' vocalizations, morphology, or breeding behavior. However, the Interior Least Tern (*S. a. athalassos*) is considered 1 of 12 subspecies of least terns worldwide (Ducey 1981) and the American Ornithologist's Union (1983) presently recognizes three subspecies in the United States. Thompson (1985a) suggests that collections of the three subspecies be examined morphometrically using multivariate techniques, electrophoresis, karyotyping, and other DNA techniques to determine differences in subspecies. Specimens of the three subspecies are available in sufficient quantity for morphometric analysis in various museum collections. However, none of these techniques would be useful in field identification.

Description

Least terns are the smallest American terns measuring from 21.6 cm to 24.1 cm long and having a wingspan of about 51 cm. The three U.S. subspecies are virtually indistinguishable morphologically and are presently distinguished by the separation of their breeding ranges (Burleigh and Lowery 1942; Massey 1976; Boyd 1983). Least terns have a black-capped crown, white forehead, a black-tipped bill, gray back and dorsal wings, white belly, and orange legs (Ridgway

1895; Watson 1966; Davis 1968; U.S. Fish and Wildlife Service 1984). Juveniles tend to have darker plumage and bill compared to adults and tend to have a dark eye stripe on their white forehead (U.S. Fish and Wildlife Service 1984).

The sexes are virtually identical. However, Boyd (1984) has developed the following four criteria for use in distinguishing the two sexes:

(1) Females usually have a wing chord less than 171 mm long while males usually have a wing chord greater than 174 mm.

(2) A male's feet are always brighter than its mate's; the male's are bright orange, while the female's are bright to pale yellow, or rarely grey.

(3) A male's bill is larger than the females's; the female's bill depth at its widest point is 4.5 mm to 5.5 mm, while the male's is 6.0 mm or greater.

(4) A male's bill is orange to bright yellow, whereas the female's bill is light or dull yellow, or straw-colored.

Due to taxonomic difficulties, the U.S. Fish and Wildlife Service is uncertain if the interior least tern qualifies as a separate subspecies. However, the Endangered Species Act allows for the listing of vertebrate subspecies or discrete populations. The interior population of least terns extending from Texas (except areas within 50 miles of the Gulf Coast) northward to North Dakota was placed on the Endangered Species list on 27 June 1985 (U.S. Fish and Wildlife Service 1985a, 1986c). The Least Tern is also protected under the Migratory Bird Treaty Act. The provisions of these laws make it illegal to take, possess, sell, deliver, carry, transport, or ship the bird, its parts, eggs, nests, or young. Critical habitat may also be protected, but none has been designated (U.S. Fish and Wildlife

Service 1984, 1985a, 1986c). The California subspecies has been listed as federally endangered since 1970 (Wilbur 1974). In addition, Illinois, Texas, South Dakota, Iowa, Missouri, Nebraska, Kansas, Colorado, Kentucky, and Tennessee presently consider the interior least tern (officially or unofficially) as State-threatened or endangered (Ducey 1981).

Life History

Migration

Least terns are migratory. They travel in small, loose flocks and arrive gradually at the ternery. In the central Mississippi drainage they usually arrive from mid-May (in Tennessee) to late May (in Illinois), although birds have occasionally arrived in late April (Hardy 1957). Tern arrival has been recorded on 19 and 25 May, at Sioux City and Council Bluffs, Iowa (Youngworth 1930; Wilson 1984). In central Nebraska, arrival has been recorded in early to mid-May (Dinan 1982; Faanes 1983), and reportedly varies from 24 April to 25 May, near Lexington (Wycoff 1960). Departure from the colony varies widely according to the season, area, and time of nesting. Hardy (1957) noted that all terns from Bell Island in southern Illinois had left by 27 July. Stiles (1939) noted that terns in Iowa did not usually leave until early September, but departure from Sioux City, has been reported before 1 September. Departures from colonies in Jackson and Gallatin counties in southern Illinois and from one colony near St. Louis, Missouri, have been recorded on 30 and 31 August, respectively (Bent 1921; Hardy 1957).

Migration Habitat Requirements

Migration habitat characteristics have not been studied in any detail as they have not been described in the literature. However, it appears likely that these terns use similar types of habitat as are used for nesting, resting, and foraging during the regular breeding season. Three interior least terns

were spotted during a spring 1983 survey at a borrow pit pond in Louisiana near the Mississippi River (Environmental Laboratory 1986). Presumably, the terns were migrating through the area and were using the pond for foraging or were resting on the open, grazed shoreline.

Roosting Habitat

California least terns reportedly use night roosting sites located away from nesting areas for several weeks before nesting. These consist of wide, open, sandy beaches (Massey and Atwood 1982; Atwood 1983). This is believed to be an anti-predator behavior which directs attention away from nesting areas prior to nesting. This behavior has not been documented in the interior subspecies.

Breeding Behavior and Breeding Habitat Requirements

Reproductive behavior begins as soon as the birds arrive at the breeding grounds in the spring, provided the site is not flooded (Hardy 1957; Tomkins 1959). Interior least terns require open expanses of sand or pebble beach along river banks and reservoirs. Sandbars, islands, and dikefields are used for courtship and nesting. Terns choose sites that are well-drained and well back from the water line. Individual nests are usually near small ridges or pieces of driftwood (Bent 1921; Hardy 1957; Tomkins 1959; Ducey 1981; Anderson 1983; Evans 1984; Dryer and Dryer 1985; Landin et al. 1985). Interior least terns usually nest on sites totally devoid of vegetation, but have been found on sites with an average of 11.4 to 30.4 percent vegetative cover (Hardy 1957; Anderson 1983; Faanes 1983; Schulenberg and Ptacek 1984; Dryer and Dryer 1985; Landin et al. 1985; Rumancik 1985). This limited vegetation was composed of grasses, shrubs, and trees and ranged from 38.7 to 94.5 cm in height (Wycoff 1950; Faanes 1983; Dryer and Dryer 1985; Rumancik 1985; Smith and Sheperd 1985). These site characteristics are similar to those associated with the coastal subspecies (Craig 1971; Jernigan 1977; Jernigan et al. 1978; Thompson and Slack 1982; Gochfeld 1983).

Vegetation, if present, is usually located well away from the colony (Hardy 1957; Anderson 1983; Rumancik 1985; Smith and Sheperd 1985). However, bugseed (*Corispermum hypssopifolium*), eastern cottonwood (*Populus deltoides*), and sandbar willow (*Salix interior*) are commonly found within or near some interior least tern colonies (Wycoff 1950; Faanes 1983; Evans 1984; Dryer and Dryer 1985). Thompson (1982) reported that vegetation associated with coastal least terns in Texas is usually clumped and scattered. This type of growth form appears to be particularly important for protection of young chicks from weather extremes and predators (Hardy 1957; Jernigan et al. 1978; Thompson 1982; Minsky et al. 1984; Schulenberg and Ptacek 1984) while not substantially obscuring the site vertically or horizontally.

Several phases of courtship behavior have been described for least terns. These behaviors appear to be similar for all three U.S. subspecies (Hardy 1957; Massey 1976). These behaviors include: aerial glides (or fish flights), posturing, parading, copulation, and nest building. Hardy (1957), Wolk (1974), and Ducey (1981) give descriptions of these behaviors. However, some variations in these courtship behaviors in the eastern subspecies have been reported by Von Schmidt (1968). Courtship may occur in different areas than those used for nesting. Eastern least terns in Georgia prefer elevated places near river banks, old logs, piling tops, and concrete bridge railings for courtship activities and these areas may be several miles from the nesting area (Tomkins 1959).

Nests are constructed by scraping a depression in an open expanse of sandy beach or mudflat. This process has been labeled "scrape-making." The scrape may be lined with small pebbles, shell fragments, or similar materials. The nest is built by both sexes and may be built before or after copulation. As natural nesting sites (islands and sandbars) have become scarce the interior subspecies has used dredge islands, dikefields, fly-ash lagoons, sandpits, and a gravel road on top of a levee (C. Iverson,

Division of Fish and Wildlife, Indiana Department of Natural Resources, West Lafayette, personal communication; Moser 1940; Wycoff 1950; Swanson 1956; Wycoff 1960; Faanes 1983; Wilson 1984; Landin et al. 1985). The coastal subspecies has even been reported nesting on roof-tops and gutters of buildings (Downing 1973; Fisk 1975; 1978a; 1978b; Thompson and Forsythe 1979; Jackson and Jackson 1985), at airports (Anderson 1972; Atwood et al. 1979), on old parking lots, road shoulders (Texas Waterbird Society 1982; Gochfeld 1983), and cultivated fields (Nugent 1974). Site tenacity for the American subspecies has been reported as varying from weak to strong (McNicholl 1975; Boyd 1984; Boyd and Thompson 1985; Burger 1984). Interior least terns usually do not nest in compact groups like other terns. Nests within a colony are scattered, varying from 21 m to 171 m apart (Stiles 1939; Hardy 1957; Anderson 1983) and territorial disputes are uncommon. Only the area immediately surrounding the nest is defended. Once mobbing behavior is initiated against a predator, the entire colony may participate (Hardy 1957; Massey 1974; Jackson and Jackson 1985). In some areas, interior least terns are found associated with piping plovers (*Charadrius melodus*) and snowy plovers (*C. alexandrinus*; Hardy 1957; Dinan 1982; Faanes 1983; Boyd 1984; Wilson 1984; Ducey 1985). These species all have similar nesting habitat requirements and may compete for nesting sites.

Least Tern eggs are pale buff to olive buff and are speckled or streaked with dark purplish-brown, chocolate, or blue-grey markings (Hardy 1957; Paige 1968; Wilbur 1974; Ducey 1981). The clutch size varies from one to four eggs, but usually two or three are laid (Hardy 1957; Anderson 1983; Faanes 1983; McCament 1985; Smith 1985; Sweet 1985). Incubation begins with the laying of the first egg, consequently, the eggs do not hatch at the same time. Both parents take part in incubation, but the female expends the most effort (Hardy 1957; Tomkins 1959; Davis 1968; Paige 1968; Ducey 1981). Incubation normally varies from 20 to 25 days (Hager 1937; Hardy 1957;

Davis 1968; Swickard 1971; Massey 1972; Anderson 1983), but extremes ranging from 17 to 28 days have been recorded (Moser 1940; Paige 1968; Wilbur 1974; Faanes 1983).

The young are somewhat precocial and are brooded for only about 6 days after hatching. After this time they are strong enough to wander from the nest on their own. Chicks are able to fly by about 20 days after hatching, but do not become competent at fishing until after migrating from the breeding grounds in the fall. Apparently, they depend on some parental care even after they have become strong fliers (Hardy 1957; Tomkins 1959; Massey 1971, 1974). Paige (1968) has noted young eastern least terns actively foraging for themselves by about 5 weeks of age.

Feeding Behavior and Habitat

The coastal subspecies of least terns and the related European little tern have been observed eating crustaceans, insects, mollusks, small fish, sand eels (Ammodytidae), and annelids (McAtee and Beal 1912; Bent 1921; Marples and Marples 1934; Whitherby et al. 1941; Tomkins 1959; Burroughs 1966; Paige 1969; Wilbur 1974; Mosely 1976; Hays 1980; Atwood and Kelly 1984). Interior least terns feed almost entirely on small fish, primarily minnows (Cyprinidae), throughout their entire life (Youngworth 1930; Hardy 1957; Anderson 1983). Important fish prey genera include *Fundulus*, *Notropis*, *Camptostoma*, *Pimephales*, *Gambusia*, *Blanesox*, and *Lepomis* (Hardy 1957; Grover 1979; Schulenberg et al. 1980).

All U.S. subspecies prefer mainly fish and prey size appears to be the most important factor determining dietary composition rather than a preference for any particular species (Mosely 1976). Adult eastern least terns in North Carolina have been reported eating fish between 5 cm and 8 cm long and feeding newly-hatched chicks fish between 2 cm and 4 cm long (Mosely 1976). California

least terns have been observed feeding on fish between 4 cm and 9 cm long (Massey 1974). Interior least terns in Kansas ate fish between 2.5 cm and 7.5 cm long (Schulenberg et al. 1980).

Interior least terns require shallow water areas in lakes, ponds, and river backwater areas with abundant small fish populations near the nesting area (Ganier 1930; Youngworth 1930; Hardy 1957; Anderson 1983). In a study of eastern least terns in North Carolina, all 61 of the colonies observed were within 250 m of a large expanse of shallow water (Jernigan et al. 1978). In Georgia, eastern least terns foraged at a maximum distance of 410 m from the colony (Tomkins 1959). Interior least terns in Nebraska generally were observed foraging within 100 m of the colony (Faanes 1983).

Range

Interior least terns formerly ranged northward along the Colorado, Red, Missouri Arkansas, Mississippi and Ohio river systems from central Louisiana to central Mississippi, central Texas, Arkansas, western Tennessee, western Kentucky, Missouri, northern Illinois, central Iowa, southern Indiana, Oklahoma, Kansas, central North Dakota, South Dakota, Nebraska, southeastern Wyoming, eastern Colorado, and eastern New Mexico (Youngworth 1930, 1931; American Ornithologist's Union 1957; Hardy 1957; Anderson 1971; Downing 1980; Ducey 1981; American Ornithologist's Union 1983; Ducey 1985). Interior least terns have also been reported incidentally in Montana, Michigan, Minnesota, Wisconsin, Ohio, and Arizona (D. L. Flath, Research Bureau, Montana Department of Fish, Wildlife, and Parks, Bozeman, personal communication Campbell 1935; Jung 1935; Mayfield 1943; Phillips et al. 1964; Skaar 1974; Monson and Phillips 1981; Janssen 1986). In most of these cases these terns appeared to be post-breeding wanderers or migrants. Many were young-of-the-year. However, several of the sightings in the western part of Arizona

may have actually been California or Mexican (*S. a. mexicana*) least terns.

In recent years the interior least tern's range has been greatly reduced. There have been no recent breeding reports from Louisiana, most of Iowa, and most of Missouri. Its range has decreased greatly in the states where it still breeds (Thompson and Landin 1978; Ducey 1981; Missouri Department of Conservation 1984; Schulenberg and Ptacek 1984; Ducey 1985; Landin et al. 1985; Parks 1985; Smith 1985; U.S. Fish and Wildlife Service 1985a).

Currently, the interior least tern breeds (Figure 1) along the Yellowstone River in western North Dakota, the Missouri River in central North Dakota, South Dakota, western Iowa, and northeastern Nebraska (including Lake Oahe and Gavins Point Dam areas), the Cheyenne River in western South Dakota, the Niobara and Platte rivers in central Nebraska, Cheyenne Bottoms Wildlife Management Area and Quivra National Wildlife Refuge (NWR) in north central Kansas, Optima NWR in northwestern Oklahoma, the Cimarron River and Edith Salt Plains in northern Oklahoma/southern Kansas, Salt Plains NWR in north central Oklahoma, the Canadian and Red rivers in northern Texas (including Hagerman NWR), Lamar and Blue lakes in Colorado, Bitter Lake NWR in New Mexico, the Pecos and Rio Grande rivers in south central Texas (including Falcon and Amistad reservoirs), the Arkansas River in central Arkansas, Kerr Dam Public Beach area on the Arkansas River in east central Oklahoma, the Mississippi, lower Ohio, and Wabash rivers in eastern Arkansas, northwestern Mississippi, southeastern Missouri, western Tennessee, western Kentucky, southwestern Indiana and southern Illinois (P. B. Hamel, Tennessee Department of Conservation, unpublished data; D. L. Henegar, North Dakota Game and Fish Department, Bismark, personal communication; J. J. Dinan, Nebraska Game and Parks Commission, Lincoln, personal communication; D. L. Howell, Iowa Conservation Commission, Des Moines,

personal communication; C. Iverson, Division of Fish and Wildlife, Indiana Department of Natural Resources, West Lafayette, personal communication; Base 1985; Fisher 1984; Landin et al., ca. 1984; South Dakota Department of Game, Fish, and Parks, unpublished report; Visser 1915; Youngworth 1930; Ganier 1930; Youngworth 1931; Stiles 1938; Seibert 1951; Brewer 1954; Ford 1956; Hardy 1957; Bailey 1965; Bohlem 1978; Kingery 1978; Thompson and Landin 1978; Grover 1979; Downing 1980; Kingery 1980; Schulenberg et al. 1980; Wingfield 1980; Ducey 1981; Kleen 1981a, 1981b; Neck and Riskind 1981; Dinan 1982; Grover and Knopf 1982; Kleen 1982; Nebraska Game and Parks Commission 1982; Schulenberg and Schulenberg 1982; American Ornithologist's Union 1983; Anderson 1983; Boyd 1983; Faanes 1983; Sweet 1983; U.S. Fish and Wildlife Service 1983a; F. L. Boyd, 1984; R. L. Boyd, 1984; Evans 1984; Hamel 1984; Landin 1984; Marlatt 1984; Missouri Department of Conservation 1984; Schulenberg and Ptacek 1984; Wilson 1984; Clark 1985; Dryer 1985; Dryer and Dryer 1985; Ducey 1985; Landin et al. 1985; McCament 1985; Nebraska Game and Parks Commission 1985; New Mexico Department of Game and Fish 1985; Parks 1985; Rumancik 1985; Schulenberg and Smith 1985; Smith and Shepard 1985; Sweet 1985; Thompson 1985a; Anderson and West 1986; Rumancik 1986).

Boyd and Thompson (1985) have found evidence of interbreeding between the eastern and interior subspecies in Kansas and Texas. In addition, the breeding ranges of these subspecies overlap and are difficult to delineate in Texas (Thompson 1985a). Interbreeding is likely in this area.

Least terns of unknown subspecies migrate through and winter along the northern and eastern coasts of South America (Venezuela and Brazil), the eastern and western coasts of Central America, and the Caribbean Islands, though exact wintering locations are largely undocumented (Hardy 1957; De Schauensee 1970; Blake 1977; Ridgely 1981; U.S. Fish

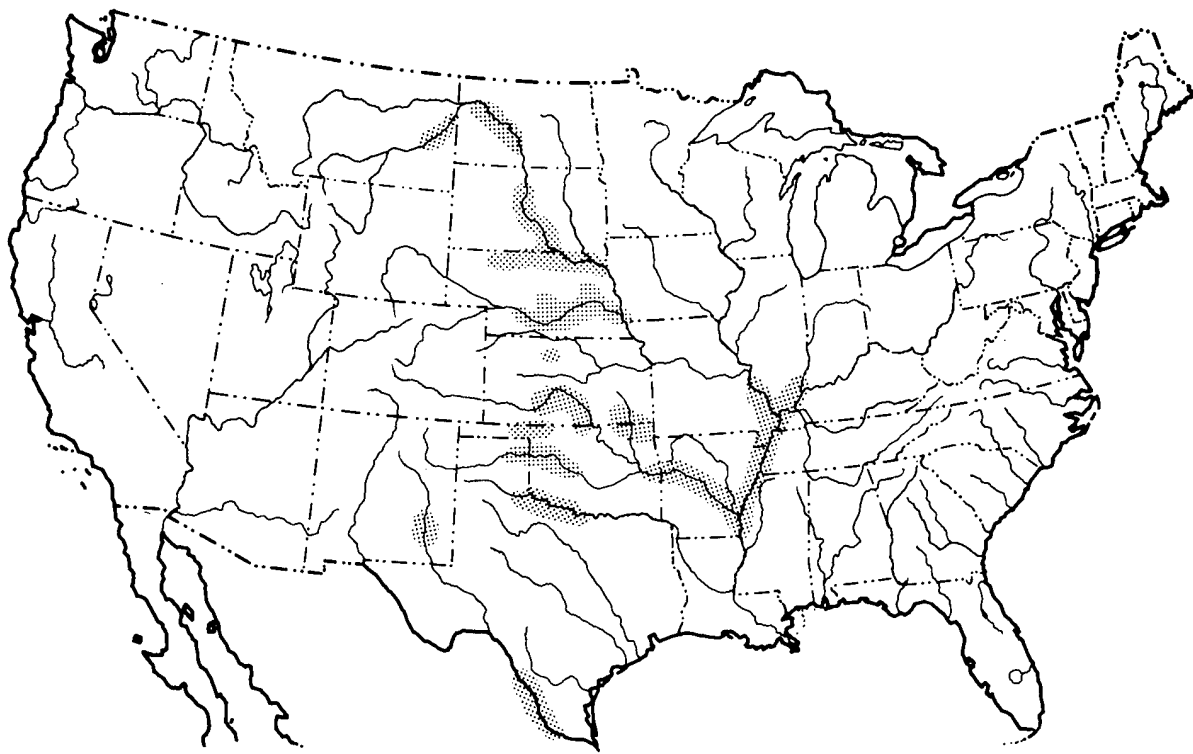


Figure 1. Breeding range of endangered interior least tern.

and Wildlife Service 1983a, 1984, 1985a). The California subspecies has been reported in Guatemala (Griscom 1932) and Veracruz (Warner and Mengel 1951).

Present Status

Downing (1980) surveyed interior least tern populations along the Mississippi, Red, Canadian (including Edith Salt Plains), Cimarron, Arkansas (including Great Salt Plains and Quivira NWRs), Republican (including Kirwin NWR), Platte, Niobrara, Missouri, and lower Ohio rivers in 1975 and the Rio Grande and Pecos rivers in 1974. He estimated the entire interior population at 1,250 birds. The greatest concentration occurred on the Mississippi River between Cairo, Illinois, and Osceola, Arkansas. In 1983, the Fish and Wildlife Service, Region 6 Office, estimated populations at 1,460-1,760+ birds (U.S. Fish and Wildlife Service 1983b) based on earlier data. Recently more comprehensive surveys have been conducted. This has been due, in part, to the recent listing of this tern as endangered. This has shifted more attention to determining the present population status and continued monitoring. At the time of Federal listing in 1985, about 1,400-1,800 terns were believed remaining (U.S. Fish and Wildlife Service 1985c).

Thompson (1985b) examined biases in present and past census techniques along the Texas coast and concluded that downward population trends in Texas in the 1970's were largely explained by differences in observer coverage and habitat changes. Surveys concentrated on where terns had been found historically and did not seek out possible new colony locations. Apparently, the terns moved in response to habitat changes, but the observers did not. These biases may have been present in past interior population surveys as well. Recently, many State and Federal agencies have conducted more extensive surveys of both known and potential habitat. Such biases should thus be counteracted and reveal more accurate population estimates. However, recent survey results have, in some cases, been difficult to interpret due to

differences in survey techniques, timing, and overlap in areas surveyed.

The Corps of Engineers and many State agencies have attempted to standardize survey techniques and data recording methods in the Mississippi River basin by coordinating surveys of different reaches at approximately the same time and using standard data recording methods. Upon reviewing available breeding season data, it is apparent that the Mississippi River basin contains the largest remaining population of terns (Table 1).

Factors Affecting Population Levels

Nesting Success Rates

Nesting success for interior least tern colonies has ranged from 2.8% to 100% (Hardy 1957; Grover 1979; Anderson 1983; Boyd 1983, 1984; Schulenberg and Ptacek 1984). Hager (1937) reported a survival rate of 9 percent for a colony of eastern least terns. California least terns have had fledgling success rates of 11% to 50% (Swickard 1971; Massey 1972). Many of the following factors affect tern nesting success.

Fluctuating Water Levels

High water can prevent or disrupt nesting (Hardy 1957; Boyd 1980; Ducey 1980; Wingfield 1980; Smith and Sheperd 1985) and can be a major cause of nesting failure if the colony is flooded between the time the eggs are laid and the young fledge (Grover 1979; Grover and Knopf 1982; Faanes 1983; Schulenberg and Ptacek 1984; Dryer and Dryer 1985). Interior least terns appear to have adapted to temporary, spring flooding of traditional nesting areas by delaying breeding until the water recedes (Ganier 1930; Hardy 1957; Ducey 1981). Thus, breeding may occur as late in summer as August. However, if the water does not recede, breeding may not be attempted at all (Hardy 1957; Landin et al. 1985), at least not at that

particular site. Large discharges from dams can also raise water levels and flood colonies during critical periods causing young mortality and nest abandonment (Dinan 1982). Interior least terns occasionally renest if the first clutch is not successful (Boyd 1983).

Weather Extremes

Extreme summer temperatures on the open nesting area can result in egg and chick body dehydration and can dry out the nearby food resources. All these factors tend to decrease chick survival (Hardy 1957; Massey 1972; Body 1980). In addition, exposure to severe storms can destroy eggs and chicks (Campbell 1979; Dinan 1982; Boyd 1984; Schulenberg and Ptacek 1984). One curious behavior has been observed which may have arisen as an adaptation to high temperatures on the nesting beach. Incubating adults have been noted leaving the nest, flying over water, plunging in, and returning to shake water onto the eggs (Mabbett 1890). Tomkins (1942) hypothesizes this to be a means of cooling the eggs by evaporation.

Predation

Predation can have a serious impact on nesting success. Grover (1979) attributed 25% to 38.5% of the observed nesting failures to coyote predation (*Canis latrans*) during a 2-year study of interior least terns. Paige (1968) noted 40% to 100% of eastern least tern chicks were destroyed by predators. Least Tern adults, chicks, and eggs have been taken by domestic cats and dogs, American kestrels (*Falco sparverius*), Norway rats (*Rattus norvegicus*), black rats (*R. rattus*), various gulls (*Larus* spp.) including laughing gulls (*L. atricilla*), red-shouldered hawks (*Buteo lineatus*), fish crows (*Corvus ossifragus*), red foxes (*Vulpes fulva*), mink (*Mustela vison*), striped skunks (*Mephitis mephitis*), boat-tailed grackles (*Quiscalus major*), great-tailed grackles (*Q. mexicanus*), feral hogs, ghost crabs (*Ocypode quadrata*), and raccoons (*Procyon lotor*; Bent 1921; Howell 1959; Tomkins 1959; Paige 1968; Craig 1971; Swickard 1971; Massey

and Atwood 1979; Minsky 1980; Neck and Riskind 1981; Burger 1984; Jackson and Jackson 1985).

Water Pollution

Pollutants entering the waterways within and upstream of breeding areas can negatively impact water quality and fish populations in nearby foraging areas. Strip mining, urban and industrial pollutants, and sediments from nonpoint sources can all degrade water quality and fish habitat, thereby impacting small-fish populations on which least terns depend (Wilbur 1974; Erwin 1983).

In addition, because least terns are relatively high on the food chain, they are in a position to accumulate contaminants which may render eggs infertile or otherwise affect reproduction and chick survival (U.S. Fish and Wildlife Service 1983b; Dryer and Dryer 1985), however the extent of this impact is undocumented. Mercury residues have been found in interior least terns from the Cheyenne River watershed in South Dakota. DDE's (a derivative of DDT) and polychlorinated biphenyls (PCB's) have also been found in the two coastal subspecies in South Carolina and California (U.S. Fish and Wildlife Service 1983b).

Human Disturbance

Recreational disturbances of active breeding colony sites by off-road vehicles, boaters, picnickers, hikers, and people exercising their pets have contributed to a decline in nesting success of all three subspecies. Increased human habitation and disturbances related to development such as public swimming beaches, marinas, industries, and farming have also contributed to a decline in nesting success (Bent 1921; Crow 1974; Ducey 1981; Nech and Riskind 1981; Dryer and Dryer 1985; Smith 1985). Many islands on the lower Ohio River are now farmed (F. Boyd, 1984; Evans 1984). Colonies in Arkansas and

Kansas have been trampled by grazing cattle (Schulenberg and Ptacek 1984, Smith and Sheperd 1985).

Threats to Habitat

Interior least terns do not occur everywhere along the rivers within their range. Hardy (1957) states that the localized pattern of distribution is the result of several factors, one being the presence of sandbars and islands with sandy beaches. The natural gradient of a river influences the number of sandbars that form and remain within the basin. Rivers that meander over a broad floodplain have a slow current and greater sedimentation rate which allow the formation of sandbars and shallow water areas suitable for nesting, roosting, and foraging.

At one time, the Mississippi's tributaries north of the Missouri River junction provided enough habitat so that terns nested there in the summer (Hardy 1957). Today, least terns have been eliminated from the upper reaches of the Mississippi and its tributaries due to loss of habitat (U.S. Fish and Wildlife Service 1984). The building of locks, dams, dikes, levees, navigation pools, storage reservoirs, as well as channel maintenance activities such as dredging by the Corps of Engineers and other agencies has drastically altered the natural forces responsible for building, maintaining, and destroying islands and sandbars along the upper Mississippi and other river systems (Hardy 1957; Downing 1980; Ducey 1981; Evans 1984; Schulenberg and Ptacek 1984). Between 1879 and 1976 the total acres of sandbars present on the Missouri River in Iowa alone decreased from 24,547 to 57 (Hallberg et al. 1979). In addition, habitat has been lost by river alterations simply because they have tended to deepen, straighten, and shorten existing river channels. The Missouri River alone lost about 230 mi of channel between 1890 and 1960 (U.S. Army Corps of Engineers, Missouri River Division, Omaha, unpublished data). In the process, sandbars and shallow water foraging habitat

were lost. Along the Missouri River an additional estimated 87,000 acres of islands and sandbars will be lost to erosion, deposition, and accretion to the shoreline by the year 2003 (Ducey 1981). Many former sandbars and islands are permanently under water while the ones remaining are no longer periodically flooded or are flooded at the wrong season. Flooding tends to erode and retard encroaching vegetation (Hardy 1957; Ducey 1981; Schulenberg and Ptacek 1984; Sidle 1984; Dryer and Dryer 1985). If natural succession is allowed to occur unchecked the area soon becomes unsuitable for nesting. Many of the more permanent extant sandbars and islands in the Mississippi, Missouri, and Ohio River basins are succeeding rapidly and no longer have open areas suitable for nesting (Ducey 1981; Dinan 1982; Evans 1984; U.S. Fish and Wildlife Service 1984).

In addition to the direct human disturbances mentioned previously, increasing river development for industrial and recreational uses is also causing a decline in available habitat (Crow 1974; Ducey 1981; Dryer and Dryer 1985). This appears to be even more of a problem for the two coastal subspecies (Wilbur 1974; Jernigan 1977).

On the positive side, some of man's activities result in land use changes that actually create more habitat. Landin et al. (1985) found 85% of the nesting colonies on the lower Mississippi River during the 1985 breeding season on Corps of Engineers' created dikefields. Whether or not this man-made habitat is preferred over more natural, isolated habitat was not determined. It may simply represent most of the suitable habitat available in the lower Mississippi during that year. Dredge material islands, sand pit mines, and construction fill sites have also been used by nesting terns (Paige 1968; Jernigan 1977; Jernigan et al. 1978), but these habitat gains are only temporary and are used until vegetation becomes established or some other disturbance keeps the birds away. It should also be noted that several studies indicate that in some parts of

the interior least tern's range, suitable nesting habitat is not limiting and for unknown reasons is not utilized (Clark 1985; Dryer and Dryer 1985; Smith 1985). In these areas it is likely some other important species requirement is lacking.

Winter Range Problems

Almost nothing is known about the loss of terns or their habitat on the winter range. Some hunting for meat has been reported in Guyana, and presumably occurs elsewhere. Hunting is apparently directed at larger species and least terns (of unknown subspecies) are taken incidentally. Habitat losses and modifications are presently unknown. However, persistent pesticides are used heavily on the winter range and could be impacting populations (U.S. Fish and Wildlife Service 1983b; Dryer and Dryer 1985). The importance of these impacts on the overall population is unknown.

Other Historic Reasons for Population Decline

One additional historic reason for declining least tern populations has been documented. Eastern least terns were slaughtered for their feathers in the late 1800's (Bent 1921; Stone 1937). The interior subspecies may have been affected as well.

Longevity

High pre-fledgling mortality appears to be offset by low adult mortality. Tomkins (1959) recovered a 5- and a 10-year old eastern least tern banded in Georgia. Massey (1973) recovered five banded California least terns ranging from 5 to 15 years old. Three of these birds were 13 years old or older. Boyd (1983) recovered two interior least terns in Kansas that were 6 years old. The oldest least tern ever recorded was a 21-year old eastern least tern (Clapp et al. 1982).

Management Considerations

Habitat manipulation and protection are the only methods available for managing least tern populations. As more habitat is lost to development, succession, erosion, river "improvement," and permanent flooding, it may be necessary to create new and rehabilitate former nesting areas. The recovery plan currently being prepared should outline a management plan to be coordinated by the Fish and Wildlife Service with the Corps of Engineers and various State agencies. Currently, no critical habitat has been designated (U.S. Fish and Wildlife Service 1985a, 1986c). The recovery plan should outline such areas along major rivers. Much of the historic habitat requires replacement, improvement, or both. Maintenance of such areas (in early successional stages) could be accommodated by allowing the Corps of Engineers to deposit dredged material every few years as part of their Operation and Maintenance Program. If properly placed, dredged material can create and maintain islands (Landin ca. 1985; Jernigan 1977; Smith 1978; Soots and Landin 1978; Ducey 1981). Landin (ca. 1985) and Smith (1978) outline design considerations for creating and maintaining dredge islands. Eastern least terns use such islands (during early successional stages) in Texas, North Carolina, Florida, and most of the Atlantic coast where natural sites are scarce (Downing 1973; Jernigan 1977; Buckley and McCaffrey 1978; Chaney et al. 1978; Parnell et al. 1978; Schreiber and Schreiber 1978; Soots and Landin 1978; Thompson and Slack 1984; Jackson and Jackson 1985). The Least Tern Habitat Suitability Index (HSI) model developed by Carrecker (1985) for use in the Fish and Wildlife Service's Habitat Evaluation Procedure (HEP) can be used as guide for evaluating an area's suitability for least terns and could aid in pointing out former habitats in need of rehabilitation or deserving critical habitat designation.

Special Management Considerations

If dredge islands are used they should be

created near shallow water areas, away from deeper, mainstream channels, in areas that would not adversely affect other significant fish and wildlife resources. The Corps of Engineers would have to adjust their dredging schedule to avoid deposition on colony sites during the nesting season (Jernigan 1977; Ducey 1981). Dredge islands should not be connected to the mainland in order to isolate the colony from terrestrial predators and human disturbances. Dredged material should be deposited high enough above the water line to prevent seasonal flooding of nesting areas, but not so high that the material does not become stabilized because of wind erosion. This range is usually about 3 feet to 10 feet above mean high water (Landin, ca. 1985; Soots and Landin 1978).

In areas where colonies suffer from human disturbances, posting signs and installing temporary fencing can keep people and vehicles out during the nesting season. Public education programs associated with these measures would also be beneficial. Public owned islands could be restricted and patrolled if occupied by a nesting colony (Landin, ca. 1985; Wilbur 1974; Jernigan 1977). However, this may not be possible in all areas due to manpower limitations, budget constraints, or other factors. In areas where predation seriously impacts nesting success, electric fences can be used to deter predators such as foxes (Minsky 1980). In other areas predator control measures such as trap and removal may prove necessary (Landin, ca. 1985; Wilbur 1974; Sidle 1984).

In areas where nesting habitat is

degraded, mowing and disking can be used to control vegetation. However, these actions are not usually feasible for interior least tern habitat due to the inaccessibility of many of the islands. Hand removal of vegetation has been effective, but is very labor-intensive. Herbicides are also effective in controlling vegetation, but the potential for contaminating nearby food resources exists. Therefore, this is probably not the best vegetation control method. Controlled burning has also proved effective in vegetation control and is considered one of the best methods available (Landin, ca. 1985; Buckley and Buckley 1976; Ducey 1981). Periodic dredge disposal at the same site can also maintain suitable open habitat (Smith 1978; Soots and Landin 1978).

Nearby foraging areas often appear to be a limiting factor for California least terns (Wilbur 1974; California Least Tern Recovery Team 1980). Therefore, efforts to control water pollution and improve water quality are important management considerations when choosing new sites to create habitat. They should be located as far away as possible from sewage treatment plants and industrial outfalls (Buckley and Buckley 1976).

Finally, little is known about the interior least tern on its winter range. If significant problems are occurring there, efforts directed at breeding range problems can not, by themselves, counter this bird's decline (U.S. Fish and Wildlife Service 1983b). The Fish and Wildlife Service, in conjunction with other governments, should attempt to determine the exact wintering range of the three American subspecies and quantify the impacts of any existing problems.

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Table 1. Results of Recent Interior Least Tern Breeding Season Surveys*

Area	1982	1983	1984	1985	1986	Reference
Mississippi River (RM 70-451)	—	—	525-539+	1334	2188	Landin et al. ca. 1984; Hamel 1984; Landin et al. 1985; Rumancik 1986; U.S. Fish and Wildlife Service 1986b.
Lower Ohio River	—	6	31	0	—	Boyd 1984; Evans 1984; Sweet 1983; Anderson and West 1986.
Arkansas River	—	—	—	186	50	Smith and Sheperd 1985; U.S. Fish and Wildlife Ser- vice 1986b.
Missouri River (North Dakota)	98	86	136	114	—	Dryer 1985; Dryer and Dryer 1985.
(South Dakota, Nebraska)	135-165	—	—	—	305	Dinan 1982; Schwalbach and Higgins 1987.
Iowa	—	—	20	20-23+	2+	Wilson 1984; D. L. Howell, Iowa Conserv. Comm., personal communication.
Platte River (Nebraska)	—	17	—	—	—	Faanes 1983.

Niobrara River (Nebraska)	112	—	—	—	—	Nebraska Game and Parks Com- mission 1982.
Oklahoma (Cimarron/Canadian Rivers, Salt Plains NWR)	200+	369+	396+	195	200	Base 1985 . unpublished report Boud 1983, 1984; U. S. Fish and Wildlife Service 1986a.
Kansas (Cimarron River and Quivra NWR)	206	80	64	—	—	Boyd 1983; 1984; Schul- enberg and Ptacek 1984.
Bitter Lake NWR (New Mexico)	**	**	8+	2	10	U.S. Fish and Wildlife Ser- vice 1985b, 1986a.
Texas (150 or more km inland)	—	—	114-128	695-745+	—	McCament 1985; Thompson 1985.
Gibson Lake (Indiana)	—	—	—	—	5	Iverson, C., Div. Fish Wildl., Ind. Dep. Nat. Res., personal communication.

* Totals include young of the year.

** Up to 15 terns have been observed there in unspecified years prior to 1984.

— Data not available.

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